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ROAD CROSSING BEHAVIOR OF AN ENDANGERED GRASSLAND BUTTERFLY, *ICARICIA ICARIOIDES FENDERI* MACY (LYCAENIDAE), BETWEEN A SUBDIVIDED POPULATION

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As high quality grasslands dwindle from degradation, habitat fragmentation increases, and urbanization expands butterflies must cope with the encroachment of human modified landscapes if they are to survive. Some butterflies have incorporated exotic larval host plants and non-native nectar resources to survive in urbanized habitats (Shapiro 2002, Graves & Shapiro 2003) while others occupy the isolated vestiges of historically dominant habitats (Severns *et al.* 2006). For butterflies to survive in human modified habitats they must successfully navigate amongst an array of unnatural physical structures like residential areas, roads, vacant lots, agricultural fields, orchards, to find adult resources, mates, and larval host plants. While some vagile, polyphagous butterflies appear to be successful in urban situations (Blair & Launer 1997) others with narrow host plant breadth and specific habitat requirements suffer as habitat modification increases. If we are to conserve, create, and maintain areas for butterflies with specialized habitat requirements, then understanding how these species respond to human modified habitats is important for conservation planning.

Fig. 1. Photograph of narrow, two-lane paved road, and hedgerow (3m - 5m tall x 100m long) separating the southern subpopulation habitat (left) and the northern subpopulation (behind the hedgerow).

Icaricia icarioides fenderi Macy (Lycaenidae), hereafter Fender's blue, is an endangered, endemic species to remnant Willamette Valley upland prairies of western Oregon, U.S.A. Fender's blue is presently known from about 15 remnant upland prairie sites (Wilson *et al.* 2003) and most of these are fragmented and isolated. About half of the remaining Fender's blue butterflies are located within the city limits and just west of Eugene, Oregon (Schultz *et al.* 2003), suggesting that conservation of this species will likely involve butterfly movement through human modified habitats (McEntire *et al.* 2007). Furthermore, Fender's blue appears to be limited to primarily local movements (Schultz 1998) and its primary larval host, *Lupinus sulphureus* Dougl. ex Hook. ssp. *kincaidii* [C.P. Smith] Phillips (Fabaceae), Kincaid's lupine, is also a locally restricted, threatened species that can be difficult to establish (Schultz 2001, Severns 2003). In the near future, Fender's blue will face the pressures of navigating through a matrix human modified habitats as open areas surrounding remnant native prairies are becoming increasingly urbanized. An understanding of how Fender's blue responds to roads and physical barriers that isolate butterfly populations and suitable grassland habitat will contribute important information to aid landscape level butterfly conservation planning.

I selected a population of Fender's blue butterfly that occupies remnant upland prairie in western Oregon, USA to study if a road and hedgerow were barriers to butterfly movement. This study site, ≈10km west of Eugene, contains one of the larger remnant butterfly populations that is bisected by a paved, narrow two-lane road, bordered on the east side by a 3–5m tall hedgerow that extends for circa 100m (Fig. 1). On either side of the road habitat conditions are similar, excepting that host plant abundance in the southern subpopulation is about 10 times greater than in the northern subpopulation. Both subpopulations are surrounded by residential areas, open water, and *Populus balsamifera* L. ssp. *trichocarpa* [Torr & Gray ex Hook] Brayshaw (Salicaceae) forests. In the spring of 2007, I recorded butterfly behavior on four separate occasions on the 7th, 8th, 26th, and 28th of May on clear, sunny days above 22°C, totaling 2 hrs and 35 minutes of observation. I recorded butterfly sex and the height from the ground, <1m and ≥ 1m, that butterflies flew as they left the southern subpopulation and crossed the road. Since all but three of the butterflies that I observed flying onto the road also crossed the width of the road (≈ 8m), I recorded the flight behavior of the butterflies when they reached the hedgerow (≈100m long x 3m–5m tall). I grouped the behavior into three flight patterns; 1) those individuals that immediately returned across the road to the prairie after encountering the hedgerow (immediate returns), 2) individuals that flew over the top of the hedgerow into the next field (emigrants), and 3) those individuals that when encountering the hedgerow tracked the length of the hedgerow for at least 5 meters before returning across the road to the original field (eventual returns). Additionally, I noted the flight heights of individuals flying from the northern subpopulation (over the hedgerow) as they flew across the road (immigrants). It is likely that individual butterflies were observed more than once and that the lack of independence was likely to be substantial enough that any statistical tests on butterfly road crossing behavior would be inappropriate, so I present the percentage of observations having recorded behaviors.

In the combined observation time of 155 minutes there were 185 road-crossing events, 161 occasions were by males and 21 occasions by females (Table 1). Under the observation conditions and duration, a Fender's blue butterfly crossed the road about once every 50 seconds. Most of the butterflies observed crossing the road from the southern subpopulation also returned to the source field when encountering the hedgerow (Table 1). All of the immigrating males that flew over the hedgerow (from the north) did not turn around when they crossed the road to head back towards the hedgerow, but rather continued on into the southern subpopulation. Most males and females from the southern subpopulation flew along the base of the hedgerow for at least 5 m before returning across the road to the original field (Table 1). Since less than 10% of females and 2% of males flew over the hedgerow from the south (Table 1), it appears that hedgerow was a more substantial barrier to movement between the two subpopulations than the road. Several other studies have demonstrated that roads do not appear to substantially restrict butterfly movement (Mungira & Thomas 1992, Ries & Debinski 2001, Ries *et al.* 2001, Saarinen *et al.* 2005, Valtonen & Saarinen 2005). However, in these studies butterflies with different dispersal tendencies also differed in their behavioral response to road edges. The more vagile, strong-flying species were less sensitive to road barriers (Mungira & Thomas 1992, Ries & Debinski 2001) than butterflies that were either habitat specialists (Ries & Debinski 2001) or those that were not efficient dispersalists (Mungira & Thomas 1992, Valtonen & Saarinen 2005). Although I did not directly measure the proportion of Fender's blue butterflies that turned before encountering the road habitat, the high frequency of road crossings suggests that the road at the study site is not likely to impact dispersal, but the hedgerow was a substantial barrier to dispersal. Since grassland butterflies have been demonstrated to be sensitive to linear objects like lines of flagging (Dover & Fry 2001), forest edges (Haddad 1999), and abrupt changes in vegetation structure (Summerville *et al.* 2002, Ries & Debinski 2001), it is not surprising that the hedgerow was a substantial barrier to emigration.

One of the primary concerns with roads, besides being a potential barrier to movement, is that roads may lead to significant butterfly mortality (Munguira & Thomas 1992, Mckenna *et al.* 2001, Ries *et al.* 2001). I only observed three occasions when cars were present on the road simultaneously with Fender's blue butterflies. On all three occasions the vehicles were traveling around 40km/hr and butterflies detected the

Table 1. Summary of male and female Fender's blue flight behavior while road crossing.

	♂	♀
total observation #	161*	21
% emigrants (southern subpopulation to north)	1.2 %	9.5 %
% immediate returns	1.9 %	4.8 %
% eventual returns	96.9 %	85.7 %
% road crossing flights <1m in height	98.2 %	100 %
% road crossing flights ≥1m in height	1.8 %	_
% immigrants crossing flights < 1m in height	94.7 %	_

* three males were observed crossing the road with oncoming cars, they flew out of the road way before crossing and are not included in this table.

movement of the cars and flew to either side of the road about 10 meters before the cars reached the vicinity of the butterflies. I also checked the road and verges on each observation date for dead butterflies and found none. When it has been measured, usually < 10% of butterflies from study populations experience direct vehicle mortality (Mungira & Thomas 1992, Ries *et al.* 2001, Valtonen & Saarinen 2005), although Mckenna *et al.* (2001) suggest that a greater proportion of mortality is possible. Anecdotal Fender's blue observations suggest that the road at the study site may not be associated with a high incidence of mortality. Since this road does not have frequent vehicle traffic, generally from 30–60 cars/day, and is relatively narrow compared with other local roads, a low incidence of vehicle-associated mortality seems reasonable. However, Fender's blue flight behavior while crossing the road suggests a greater potential for mortality on wider roads with heavier traffic and greater vehicle speeds.

Nearly all of the Fender's blue butterflies observed crossing the road did so at a height <1m from ground level, regardless of whether they were emigrants or immigrants (Table 1). It appeared that most of the individuals flew within 0.5m of the ground while crossing the road. Butterflies also made many small turns, appearing to zigzag and retrace areas of the road previously covered. This type of flight is characteristic for Fender's blue while searching for resources, especially when compared to the relatively straight, higher elevation flight when butterflies encounter unsuitable habitat (Schultz 1998, Schultz & Crone 2001). It is concerning that the butterflies in this study appeared to treat the road as a habitat with potential resources when it is clearly devoid of both nectar and larval host plants. The apparent search behavior by Fender's blue butterfly while crossing the road may place more individuals in jeopardy of vehicle mortality on busier, wider roads if the behavior documented at my study site is representative of butterfly behavior while crossing most types of paved roads. Prior studies on butterfly behavior crossing roads did not focus on the flight behavior while crossing the road but rather on whether or not the butterflies crossed the road (Mungira & Thomas 1992, Mckenna *et al.* 2001, Ries *et al.* 2001, Saarinen *et al.* 2005, Valtonen & Saarinen 2005). Height from the ground and resource searching flight behavior while road crossing is likely an important determinant in the incidence of vehicle induced butterfly mortality. Mungira and Thomas (1992) witnessed butterflies being sucked down to the level of the road by passing vehicles, which were then subsequently hit by oncoming traffic, suggesting that butterflies crossing the road at shorter distances off the ground may experience a greater chance of mortality.

Given the threats of increased habitat loss through urbanization, fragmentation of remaining habitat, and overall habitat degradation by exotic species (Severns 2007), implementation of the stepping stone reserve design for the southern Willamette Valley (Schultz 1998, McEntire *et al.* 2007) should consider the position of roads and barriers to movement. Barriers to movement, like the hedgerow in this study, are not necessarily detrimental to conservation but their impacts depend upon the landscape situation in which they occur. For example, an opaque hedgerow lining a butterfly population from a busy road may decrease mortality by encouraging butterflies to fly back into the prairie habitat when encountering the habitat edge instead of crossing a road. Hedgerows or trees lining a site may be beneficial if the butterfly population is relatively large and isolated from other suitable habitat but may be detrimental if the population is small and the physical barriers restrict local butterfly colonization. Since hedgerows can be modified through cutting/planting, ephemeral vegetation barriers could be created to aid reintroduction efforts so that dispersing butterflies are forced back into the target site, increasing site residency times of reproducing individuals. These same barriers to dispersal could also be removed or modified when the target population is considered large enough to be a stable source population, for example. The successful management and conservation of Fender's blue butterfly and perhaps many other butterfly species will rely on our understanding of how adult butterflies interact within the matrix of human modified, degraded, and higher-quality remnant habitat. Clearly the study I have presented is limited in the number of study sites that prevents a more broad set of recommendations for butterfly conservation. However, Fender's blue flight behavior suggests how butterflies cross roads may be just as important to their conservation as the choice to cross or not cross roads. Studies that compare how butterflies interact with human and natural physical barriers may prove invaluable towards conserving rare and common butterflies inhabiting a mosaic of natural and urban habitats.

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